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Stated choice valuation of aircraft noise and other environmental externalities at Bangkok Suvarnabhumi Airport

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ABSTRACT

Aircraft noise and other environmental externality effects have gained significant public attention in Thailand since Bangkok's Suvarnabhumi Airport opened in 2006. Residential areas around the airport are expanding rapidly and local residents are protesting about the noise and air pollution from the airport. This study employed Stated Choice to elicit willingness-to-pay (WTP) values to reduce aircraft noise and air pollution. The novelty of the research arises from the fact that it explores monetary values of externalities not only for those who suffer from the pollution (residents) but also those who have some responsibility for the externalities that are created (i.e. air passengers). Results indicate that passengers and residents have different priorities in terms of aviation externalities. As might be anticipated, residents place a higher value on aircraft noise nuisance than passengers at 104.76 USD and 70.63 USD per year respectively to halve aircraft noise levels. In terms of air pollution, passengers had a higher WTP at 151.18 USD against residents' WTP of 86.52 USD per year to halve local air pollution created by aircraft. Passengers are willing to pay 41.69 USD per year to offset carbon emissions. The study found that aviation growth at Suvarnabhumi was underestimated and there is an urgent need to implement environmental mitigation policies to address the issue.

Keywords: aircraft noise, environmental valuation, aviation externalities
I-INCE Classification of Subjects Number(s): 67.4

1. INTRODUCTION

This paper explores the development of Bangkok's Suvarnabhumi airport and its impacts on the environment. The airport is the largest in Thailand in terms of traffic and passengers handled and the 16th largest airport in the world in terms of passenger numbers (1). The airport opened in 2006 and passenger numbers have increased from 42.8 million that year to 51.46 million in 2013 (2). Suvarnabhumi airport presents a unique opportunity to study the tensions that exist between the socio-economic benefits of aviation growth and the associated environmental costs in a developing economy. Suvarnabhumi airport was built in a relatively rural and agricultural area to minimise the impact of noise. However, rapid airport growth and the ensuing environmental impact were underestimated. Additionally, areas surrounding Suvarnabhumi airport have seen a rapid rate of urbanisation which has an impact on local residents' livelihoods and wellbeing.

The airport provides potential benefits in terms of job and business opportunities, comparatively cheap housing development and good transportation links to city centre (with a direct rail-link and an expressway). This resulted in rapid increase in population in the area. At the same time, significant changes in noise levels have impacted on resident's welfare and have generated strong opposition to the airport. Significantly, it was the first time Thailand had experienced protests about noise pollution (3) and put aviation's impact on the environment into the spotlight. Although aircraft noise is the focus of protests by residents, aviation-related activities at Suvarnabhumi airport cause other impacts as well, including pollution at both the local (from increased road traffic to and from the airport and aircraft emissions during take-off and landing) and the global level along with other social and cultural impacts.

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This paper reports results from a study which aimed to obtain monetary valuations of aviation externalities, namely noise, air pollution and carbon emissions using a stated choice approach (SC). This is the first study to obtain values from both the perspectives of residents who are affected by airport activities and passengers who are partly responsible for the impact to compare how the two groups value aviation externalities.

1.1 Valuation of Aviation Externalities

There have been a small number SC studies on aircraft noise valuation from airport residents and carbon offsetting from air passengers. For aircraft noise, there are different ways to present it. The most popular is to use flight movements of different aircraft sizes at different times of the day which are used to proxy aircraft noise (4,5,6). Thanos, et al. (7) adopted a different approach by using experienced noise at the old and new airports in Athens while incorporating transportation access and commuting time into the SC design. Apart from these two approaches, percentage reductions in aircraft noise have also been used in Contingent Valuation Method (CVM) studies by Pommerehne (8) and Faburel & Luchini (9). A few studies have examined willingness to pay for carbon offsetting (10,11,12). As far as we are aware no studies have applied stated preference techniques to the value of air pollution from aircraft.

In the context of Thailand there are only two studies looking at the value of aircraft noise. Chalermpong (3) used the hedonic pricing method at Suvarnabhumi Airport and reported a noise depreciation index (NDI) value of 2.12% per 1dB increase in aircraft noise. This is at the top end of values in the literature where meta-analysis (13,14) found an average around 0.5 to 0.6% (NDI). This study used a relatively crude noise measurement of NEF 30 and was based on a fairly small sample of 384. Another study by Chalermpong & Klaiklueng (15) used willingness to accept compensation at Suvarnabhumi Airport for a proportional increase in flight movements using rental fee change as the payment vehicle and reported the Willingness to Accept (WTA) compensation for one flight movement increase ranged from 18.87 to 68.82 baht ($0.6- $2.22; US$ = 31 baht) per month per one flight movement change. Again this value looks high which may be a function of the WTA framing and the high proportion of students in the population interviewed. This paper reports a study covering a wide representation of residents living around the airport and examining the perspective of passengers.

2. SURVEY DESIGN AND IMPLEMENTATION

2.1 Survey design

The SC experiment was embedded in a wider social survey investigating attitudes to aviation and other environmental issues, noise nuisance and socio-economic characteristics. The experimental design of this study aimed to obtain comparable values for residents and passengers. The qualitative research undertaken as Phase 1 of this study (16) found that both passengers and residents identified three key environmental problems relating to aviation, namely, aircraft noise, air pollution around the airport and carbon emissions. As a result, the design contains four attributes namely aircraft noise, local pollution created by aircraft, carbon emissions and cost.

The first two attributes have similar levels and presentation (see Table 1). Each attribute has two improvement levels, an ‘as now’ option and two deteriorating levels presented in the form of percentage change. The levels and percentage change presentation were tested during the qualitative phase of the study and were found to be appropriate and easy to understand by the participants. The carbon offsetting attribute has two options which are yes (to offset) or no (for no offsetting). The air ticket price range has nine levels. Starting from an increase of 300 baht a flight, the rate increases at intervals of 400 baht up to 1,500 baht with the equivalent for reductions (the same range of cost changes is offered to residents but in the form of an airport impact relief scheme and as a monthly payment).

Choice cards were constructed in accordance with the D-efficiency principle (17) using the Ngene software. Resulting in 32 SC cards for each experiment these were then divided into four blocks of eight cards, such that each respondent completed eight choice cards. Each card contains three options, A, B and ‘As now’, see Figure 1 for an example.

Table 1 – Experimental Design Attributes

Attributes	Levels
Aircraft Noise	25%, 50% less noise As now 25%, 50% more noise
Aircraft Engine Emissions	25%,50% less air pollution As now 25%, 50% more air pollution
Carbon offsetting	Yes/No
Air fare/ Airport Impact Relief Scheme or payment	Increased by 300, 700, 1100, 1500 Baht As now Reduced by 300, 700, 1100, 1500 Baht

Figure1- Choice Card Example – Residents

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% louder	50% quieter	As now
Aircraft engines produce	25% less air pollution	25% more air pollution	As now
Carbon offsetting	Yes	Yes	No
Airport Impact Relief Scheme	You would pay 1,500 baht/month	You would pay 1,100 baht/month	No payment/ compensation
I would choose	A	B	C

2.2 Survey Implementation

There are two main residential areas around the airport: Ladkrabang to the north of the airport which is mostly exposed to aircraft arrivals and Bangna to the south of the airport which is mostly exposed to departing aircraft. The sample was gathered from residents living within the NEF30 and over contour (approximately Leq 65) in Ladkrabang and Bangna. To identify the affected areas, a noise contour map published by Airports of Thailand plc (AOT) in 2007 was used as a reference as it was the latest version available. There are 32 affected communities in the Ladkrabang area and 20 affected communities in Bangna. The resident sample size was 206.

The passenger survey was conducted at the gate areas of the departure hall at Suvarnabhumi Airport. The respondents were 400 Thai passengers flying from Bangkok's Suvarnabhumi airport. They included passenger flying economy class and business class as well as customers of low cost airlines and passengers who were flying for business purposes. Both surveys were conducted in 2012.

3. RESULTS

The SC data were estimated using Multinomial Logit Model (MNL) using the Nlogit5 software. Initially for each exercise, a base model with all respondents was estimated.

The resident exercise contains three environmental attributes. Percentage changes in aircraft noise (NOISE) and local air pollution (AIR) were used as to represent local environment problems relating to Suvarnabhumi Airport. A carbon offsetting option (OFFSET) was also added to the design to align it with the air passenger exercise to facilitate easy comparison between the two groups of respondents. COST and GAIN represent the airport environmental impact reduction scheme where cost represents fee and gain represents compensation. The base model is shown in Equation 1 below.

$$U_i = ASC + \beta_1 NOISE + \beta_2 AIR + \beta_3 OFFSET + \beta_4 COST + \beta_5 GAIN + \varepsilon \quad (1)$$

Table 2 shows the results from the base and restricted models which are discussed in turn.

Table 2 – Resident MNL models

	Base Model		Restricted Model	
Variables	Coefficients	Z-value	Coefficient	Z-value
NOISE	-0.00480***	-5.00	-0.00509***	-5.20
AIR	-0.00208*	-1.91	-0.00222**	-1.98
OFFSET	0.07591	1.11	-0.07590	1.09
COST	-0.00055***	-4.71	-0.00067***	-4.91
GAIN	0.00023**	2.03	0.00016	1.18
OPTION A	0.01280	0.11	0.79606***	5.55
OPTION B	-0.41556***	-3.47	0.34107**	2.33
Adjusted R^2		0.0291	0.0389	
Log-likelihood		-1725.82	-1360.30	
Sample size		206	164	

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

In the base model all attributes except offsetting (OFFSET) are statistically significant. This allows WTP and WTA to be calculated by dividing the coefficient of the relevant attribute by the cost coefficient for WTP and dividing by gain coefficient for WTA (see Equation 2).

$$WTP = \beta NOISE / \beta COST \quad (2)$$

This gives a WTP to reduce aircraft noise by 1% of 8.73 baht a month and WTP to reduce local air pollution is 3.78 baht a month. This suggests that residents value the aircraft noise problem more than twice as much as that of local pollution which is in line with the results from the qualitative phase (14) and other sections of the questionnaire that suggest aircraft noise is perceived as the worst problem arising from aviation. Residents are willing to accept compensation of 20.87 baht for every 1% increase of aircraft noise and 9.04 baht for 1% increase in local air pollution per month this means that the WTA values for both noise and local pollution are more than double the WTP values.

A restricted sample was then estimated by removing non-traders from the model. The model removed any non-traders from the sample (i.e. the respondents who only chose option C in the question card which is a status quo option). The reason for the restricted model estimation is to remove a number of respondents who were possibly not fully engaged with the questionnaire which could be caused by fatigue, disinterest in the study or choice complication, status quo bias or other reasons. It was expected that the restricted model will improve the model fit and improve coefficient statistical significance in comparison to the base model. There were 42 non-traders (20.39%) therefore a total of 164 respondents were included in the estimation which sees an improvement in adjusted R^2 from 0.0291 to 0.0389. The coefficients on cost and noise are broadly similar to the base model but the gain coefficient loses significance. As a result the WTP for aircraft noise reduction by 1% is 7.60 baht a month and the WTP for local air pollution is 3.31 baht. Although, the restricted model has a better fit, the values obtained are very similar to the base model and we use that for value derivation as it retains the whole sample.

The base model for the passenger experiment contains four attributes as specified in equation 3. These are aircraft noise (NOISE), local air pollution (AIR), carbon offsetting (OFFSET) and changes in airfare (COST). A total of 345 from respondents were included in the model. Initially, there were

400 respondents but those who did not state the airfare were removed. There were only 20 non-traders in passengers group and the restricted model run but there was minimal change to the result and therefore only full model is reported. As mentioned earlier, the SC card design for passengers is identical to the resident model to allow comparison between the two groups. The only difference is the payment vehicle in which changes (increases or decreases) in airfares are used in the passenger exercise to represent cost.

$$U_i = ASC + \beta_1 NOISE + \beta_2 AIR + \beta_3 OFFSET + \beta_4 COST + \varepsilon \quad (3)$$

The results of the passenger exercise are illustrated in Table 3 which shows that all of the attributes are statistically significant at 1% confidence interval. The model fit is reasonable.

Table 3 – Passengers MNL Models

Variables	Coefficients	Z-value
NOISE	-0.01037***	-12.50
AIR	-0.01435***	-16.46
OFFSET	0.17984***	3.30
COST	-0.00038***	-13.15
OPTION A	-0.18399***	-3.34
OPTION B	-0.02680**	-0.49
Adjusted R^2	0.0611	
Log-likelihood	-2818.67	
Sample size	345	

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

WTP for 1% reduction of aircraft noise is 27.29 baht per flight and WTP for 1% reduction in local air pollution is 37.76 baht per flight. These values show a different view of passengers in terms of severity of externalities in comparison with local residents as passengers value local air pollution more highly than aircraft noise. Since the offsetting coefficient is significant in this model, it is possible to calculate the willingness to pay for carbon offsetting and the value is 473.26 baht per flight.

4. DISCUSSION

An important aspect of this study was to produce comparable values between residents and passengers to see how the polluters and polluted value the same environmental problem. Here we standardise the values by converting WTP/WTA into annual values.

Firstly, the residents' monthly WTP/WTA values from the base model were multiplied by 12. The base model was used as both cost and gain coefficients are statistically significant. Secondly, the average annual number of trips for passengers of 2.588 trips as derived from our survey of was used to adjust the per trip valuations. Values are estimated from the base models and reported in Table 4.

Table 4 – Standardised Values (Baht, per year)

	Passenger	Resident	
	WTP	WTP	WTA
Aircraft Noise	70.63 /1% reduction	104.76 /1% reduction	250.44 / 1% increase
Local Air Pollution	97.72 /1% reduction	45.36 / 1% reduction	108.48 / 1% increase
Carbon Offsetting	1,244.80	-	-

The standardised values show that residents' WTP for noise reduction is 48.32% higher than that of passengers. This was expected. Airline passengers' WTP for air pollution reduction was 115.43% higher than the corresponding figure for local residents. Residents WTA values are higher than WTP as expected but the ratios are relatively low in both cases less than 2.5 to 1. It is notable that for air pollution the passenger value lies between the residents WTP and WTA whereas for noise the passenger value is always lower.

The noise results from this study were compared with WTP measures estimated by four previous studies that obtain a 50% noise reduction valuation. The values for each study were adjusted to allow for local inflation and GDP growth. The value was first adjusted by adding GDP growth rate of the country of study from the year of study to 2013. Secondly, the value was increased by inflation rate from the same period. Once this is complete, the value is converted to US dollar using 2013 exchange rate. All of the previous studies reported in Table 5 are located in Europe. Thune-Larsen (1995) employed both Contingent Valuation and Stated Choice methods for Oslo airport, and that study reports the highest WTP values, while the lowest WTP value was found among Athens airport residents (28.19 USD per year). However the Athens values will have been particularly affected by negative GDP growth in the recent recession.

According to airport trade organisation Airports Council International (15), Suvarnabhumi Airport is the largest airport among those examined in these studies in terms of passengers and cargo handled. At 104.76 per year, the WTP of Suvarnabhumi residents is the third highest of the five and the estimated figure is in a comparable range with Paris Orly Airport residents of 109.24 USD. Passenger's WTP from this study is 70.63 USD. As this is the only study that obtains air passenger's WTP to reduce aircraft noise, there are no comparable values.

Table 5 – WTP for 50% reduction of aircraft noise (USD 2013 values)

Study	Data Year	Location	Remark	WTP/Year (USD)
Pommerehne (1988)	1988	Basel	CV	54.07
Thune-Larsen (1995)	1994	Oslo	SC	190.93-948.29
			CV	218.21-740.47
Faburel & Luchini (2000)	1998	Paris Orly	CV	109.24
Thanos et al (2011)	2005	Athens	SC	13.2
This study	**2012**	**Bangkok**	**Residents**	**104.76**
			Passengers	**70.63**

In terms of carbon offsetting, three previous relevant studies were found and compared in Table 6. There are two studies in Europe and one in Asia. As values are from various years, the WTP values were again adjusted to 2013 values. The values from our study are lower than the European WTP but they are comparable with the Asian study (11).

Table 6 – WTP for carbon offsetting (USD 2013 values)

Study	Location	Route/sector	WTP/Flight (USD)
Brouwer et al (2008)	Amsterdam	n/a	38.60
Mackerron et al (2009)	UK	New York to London	45.10 (CV) 45.65 (SC)
Lu & Shon (2012)	Taipei	China	5.62
		Far East Asia	9.89
		Southeast Asia	12.14
		Western	18.88
This study	**Bangkok**		**16.11**

5. CONCLUSIONS

This study is the first to identify values of aviation externalities for both the affected residents and airline passengers in a developing country. The findings show that residents place the highest value on noise reduction whilst passengers value air pollution reduction more highly which suggest that the perceptions in terms of priority and severity of aviation externalities differ between the two sides. The values are broadly in line with available comparable studies. However, the noise values are relatively high given income levels.

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